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Roller for plier tips of blood transfusion stripper tool - has concave surface to provide self-centring action for tube being squeezed

BAXTER TRAVENOL LABS INC 13.03.78-US-885664
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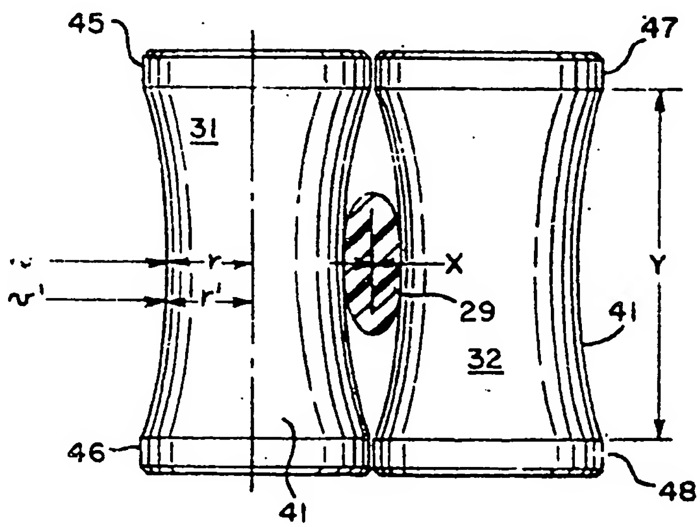
A pair of self-centering rollers are mounted on a tool that progressively collapses a resilient tube to advance a liquid through the tube. Each of the rollers has a concave surface, with the depth of the groove being similar to the wall thickness of the tubing so that the tube becomes fully collapsed when the tool is closed. Pref. the roller concave surface defines a portion of a circle.

The curved roller can be used with a pliers-like tool which is moved along a tube carrying blood from a donor. The tool empties the tube into the blood collection vessel. In another embodiment, the curved roller is used in a peristaltic pump. (21pp Dwg.No.5)



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(54) SELF-CENTERING ROLLER CONFIGURATION FOR FLUID-TRANSFERING MEDICAL EQUIPMENT

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SPECIFICATION

Background and Description of the Invention

The present invention relates generally to improvements in roller configurations for enhancing the usefulness and reliability of devices that move blood and the like through flexible tubing. More particularly, the invention provides a concave, curved-surface roller configuration at the working locations of blood donor tube strippers. In another aspect of this invention, such configuration is also useful for rollers within blood pumps and the like, whereby tubing guide means typically present therein may be omitted in order to simplify the construction of the blood pump without diminishing its overall pumping capabilities.

Blood, other body fluids, and medication have long been transported from one location to another through deformable, resilient tubing by using rollers movable along a length of tubing to constrict the tubing in order to push the fluid through said tubing length. One well-known application of this general approach is in connection with tube strippers, which can be in the form of pliers-like tools for forcing blood through the tubing used in collecting blood from donors. Most commonly, such tube strippers are needed after the donation apparatus has been disconnected from the donor, the tube stripper being used to force the blood remaining within the donor tube into the blood collection package.

SELF-CENTERING ROLLER CONFIGURATION
FOR FLUID-TRANSFERING MEDICAL EQUIPMENT

Abstract of the Disclosure

Rollers for moving blood or other fluids through resilient tubing are improved by a curved surface configuration which will automatically center the tubing longitudinally along the roller and create a differential surface velocity when in operation in order to urge the tubing to the center of the roller and maintain its location there. This improved configuration enhances the ease of use of blood donor tube strippers and the like, enhances their relibility, and makes them more durable products which are less susceptible to maladjustment both when manufactured and when in use.

Prior art tube strippers are described in Sanderford U.S. Patent No. 3,194,452 and Engelsher U.S. Patent No. 3,847,370. Pliers-like tube strippers having a configuration such as that shown in Figure 2 of the present application are also known in the art. When such tube strippers are used in the field by nurses, doctors, and medical technicians, serious difficulties are encountered in guiding the rollers of the stripper along the length of tubing so that the rollers will maintain a true track without slipping off center. When the rollers of a tube stripper do not accurately track down the tube, the tube stripping operation is only partially effective since the tube will not always be completely compressed, meaning that the blood will not be thoroughly stripped from the tubing. On some occasions, this imprecise tracking will result in damage to or cutting of the tubing which can contaminate the donated blood unit. To avoid this undesirable imprecise tracking, the user of these prior art tube strippers must carefully control the device, which requires a significant amount of concentration and dexterity.

These prior art tube strippers also tend to be susceptible to maladjustment after numerous uses, especially if the devices have been subjected to extensive imprecise tracking along the extreme ends of the rollers, thereby urging the rollers to loose their initially manufactured parallel relationship with each other. Disturbing this parallel relationship between the rollers when they are in their stripping orientation considerably increases the difficulty of accurately

tracking the tube stripper along length of tubing.

Other well-known applications for rollers of the general type for which the present invention is an improvement include their use within blood pumps, roller pumps, and other medical uses calling for the transfer of liquid through a length of deformable tubing by compressing that tubing with a roller which rotates on its axis. A prior art blood pump is illustrated generally in Figures 5 and 6 of this application. Rollers within blood pumps and the like generally develop difficulties similar to the rollers of tube strippers. The problems associated with erratic tracking is generally solved in the prior art by including guide rollers, clamps, straps, or the like for maintaining the tubing near the center of an axis of axially stabilized rollers within the pump. By using the roller configuration in accordance with the present invention, such additional guiding or locating means can be eliminated since the rollers themselves will automatically maintain the tubing at the center of the rollers' axes.

These tracking, difficulty of use, and durability problems are substantially eliminated by the present invention which configures a tube tracking roller in an especially advantageous manner so that the roller automatically centers the tubing along the roller's axis and constantly urges the tubing to remain centered when external forces cause tracking misalignment such as when the user of a tube stripper inadvertently deviates somewhat from a path closely following

the tubing being stripped. The improved structure includes rollers having concave, curve-contoured surfaces of a precisely determined cross-sectional radius of curvature.

It is accordingly a general object of the present invention to provide an improved, self-centering roller for use in medical equipment.

Another object of the present invention is an improved roller configuration for a blood donor tube stripper significantly improved in its ease of use and reliability for removing blood and the like from transfer tubing of medical equipment.

Another object of this invention is an improved roller stripper which requires less critical adjustment parameters, is a more durable product, and is less susceptible to maladjustment than other roller strippers.

Another object of the present invention is an improved roller for use within a blood pump or medical equipment roller pump to impart the rollers with a self-centering feature which permits the elimination of guide rollers, clamps, straps and the like for maintaining the proper location within the pump of the transfer tubing being acted upon.

These and other objects of the present invention will be apparent from the following detailed description taken in conjunction with the accompaning drawings, wherein:

Figure 1 is a perspective view of a blood donor tube stripper made in accordance with the present invention;

Figure 2 is a perspective view, partially cut away, of a prior art blood donor tube stripper of which the stripper shown in Figure 1 is an improvement;

Figure 3 is an enlarged plan view, partially cut away in cross section, of one of the preferred curve-contoured rollers as mounted at the working end of the tube stripper shown in Figure 1.

Figure 4 is a view taken along the line 4-4 of Figure 3;

Figure 5 is an enlarged elevational view of the preferred rollers of Figure 1, shown in their coacting, working relationship;

Figure 6 is a schematic top plan view of a roller pump in accordance with the prior art and from which a portion of the top guide roller has been omitted for clarity;

Figure 7 is a view generally along the line 7-7 of Figure 6 with the top guide roller being shown in its entirety;

Figure 8 is a schematic top plan view of a roller pump having the curve-contoured rollers in accordance with the present invention; and

Figure 9 is a view generally along the line 9-9 of Figure 8.

Figure 1 illustrates the preferred embodiment of this invention, an improved blood donor tube stripper, generally designated as 11, including a first pliers arm 12 and a second

pliers arm 13, pivotally joined to each other by a pivot rod 14 which is rigidly connected to and laterally extends from the first pliers arm 12 and through a lateral pivot bore 15 in said second pliers arm 13. Preferably, one of the pliers arms, for example first arm 12, has a transverse, threaded bore 16 therethrough having a set screw 17 therein, which set screw 17 is threadedly movable through the bore 16 until it projects therefrom for abutment with an inside surface 18 of the second pliers arm 13, whereby the set screw 17 serves as an adjustable stop between the working end 19 of the first pliers arm 12 and the working end 21 of the second pliers arm 13, when the gripping or handle ends 22, 23 of the first pliers arm 12 and the second pliers arm 13, respectively, are squeezed toward each other when the tube stipper 11 is in working use.

Laterally projecting from the working end 19 of the first pliers arm 12 is a first pivot pin 24, and laterally projecting from the working end 21 of the second pliers arm 13 is a second pivot pin 25. Each pivot pin 24, 25 includes a pivot shaft 26 rigidly secured, such as by threading, into the working ends 19, 21, while the remote ends of the pins 24, 25 have enlarged heads 27, 28, respectively.

A section of deformable, resilient transfer tubing 29 is shown in Figure 1 being stripped by the tube stripper 11, and more particularly by the coacting curve-contoured rollers 31, 32 that are pivotally mounted upon the first pivot pin 24 and the second pivot pin 25, respectively. Downstream of

the rollers 31, 32, when the tube stripper 11 is in use, the transfer tubing 29 will have blood or other fluid 33 therewithin, while upstream of the rollers 31, 32 the transfer tubing 29 will be substantially completely stripped of the blood or other fluid 33.

Figure 2 illustrates a prior art tube stripper, generally designated as 34, wherein the first pivot pin 24 has pivotally mounted thereon a first spool 35, and wherein the second pivot pin 25 has pivotally mounted thereon a second spool 36. Each of spools 35, 36 include a right cylindrical surface 37 and a top and a bottom cylindrical flanges 38, 39, respectively. In use, the tube stripper 34 must be slowly and carefully tracked along the transfer tubing 29 so that it remains in contact with the right cylindrical surface 37 only to avoid contact with either the top cylindrical flange 38 or the bottom cylindrical flange 39. When such flanges 38, 39 are contacted by the transfer tubing 29 as the spools 35, 36 rotate in use, the tubing 29 will then be tracked by an uneven rotating surface since the cylindrical flanges 38, 39 are of a larger diameter than the right cylindrical surface 37. Occasionally, especially when the user is not very careful, the tracking surface will move farther off-center and include the non-rotating cylindrical surfaces of the first and second enlarged heads 27, 28, which typically will so skew the tracking path that the transfer tubing 29 completely disengages itself from the tube stripper 34 due to the generation of a greater

amount of friction, or drag, between the transfer tubing 29 and the non-rotating pivot pin heads 27, 28 than the rolling friction developed between the transfer tubing 29 and the rotating top cylindrical flanges 38.

Even when a user of tube stripper 34 is skillful enough to avoid such severe skewed tracking, the rotating spools 35, 36 do not automatically urge the transfer tubing 29 therebetween toward their axial centers, with the very common result that the transfer tubing 29 will move from the rotating even right cylindrical surfaces 37 to the uneven rotating surfaces including both the cylindrical surfaces 37 and either the top cylindrical flanges 38 or the bottom cylindrical flanges 39 and perhaps then back to the even rotating surfaces 37. Such movement between the even and the uneven surfaces means that, since some of the blood or other fluid 33 will not be stripped from the transfer tubing 29 by the uneven surface, the total stripping efficiency of the tube stripper 34 will be reduced. In some instances, the top cylindrical flanges 38 or the bottom cylindrical flanges 39 forming a portion of these uneven surfaces will actually be operating as a blunt, rotating knife-edge that will cut into or otherwise damage the transfer tubing 29, often destroying the sterility of the blood or other fluid 33.

A curve-contoured roller 31 in accordance with this invention is shown in greater detail in Figures 3 and 4 mounted upon the pivot pin 24 having pivot shaft 26 secured

to the working end 19 of the pliers arm 12 and the enlarged head 27 for retaining the roller 31 on the pivot shaft 26. Roller 31 has a contoured surface 41 which is generally concave in configuration and preferably arcuate in cross section. Roller 31 includes a longitudinal bore 42 having a diameter slightly larger than the outer diameter of the pivot shaft 26 to allow for easy rotation of the roller 31, the difference between these diameters being somewhat exaggerated as shown in Figure 3. Longitudinal bore 42 will preferably have a counter-sink 43, 44 at both ends to facilitate rotation of the roller 31 along the shaft 26. Usually, the contoured surface 41 will terminate at generally right cylindrical flanges 45, 46 which oppose like flanges 47, 48 on the other roller 32 (Figure 5). Preferably, by adjusting set screw 17, opposing flanges 45, 47 and 46, 48 will have a clearance therebetween, which flange clearance will permit either no engagement of the flanges or only a glancing engagement to avoid or greatly minimize any friction development as rollers 31, 32 rotate.

Figure 5 illustrates the preferred configuration of the curve-contoured rollers 31, 32 especially when they are designed to rotate together in stripping the transfer tubing 29. Preferably, the concave surfaces of rollers 31, 32 have a longitudinal cross section that is a circular segment of radius R exhibiting a particular relationship with the longitudinal extent or chordal length Y of the contoured surface 41 and another dimension X, which is the height of the circular segment plus one-half of the flange clearance, or one-half of the greatest distance between the rollers 31, 32 and which is equal to or less than the wall thickness

of the transfer tubing 29. This relationship can be expressed by the following equation:

$$R = \frac{Y^2 + 4X^2}{8X}$$

The dimension X is preferably less than the transfer tubing 29 by an amount, an occlusion factor, which is determined by the tubing material and its wall thickness so that the squeezed tubing itself will be adequately compressed to clearly strip the transfer tubing 29. With this preferred relationship, the rotating rollers 31, 32 will squeeze the tubing 29 to such an extent that the walls thereof are themselves compressed, which will develop a force greater than that possible without compressing the walls, which force is transmitted to the blood or other fluid 33 as an improved stripping force. This effect is achieved when the radius R is calculated according to the preceeding formula by substituting a value of X which is the undeformed wall thickness of the transfer tubing 29 minus the occlusion factor.

The self-centering attributes of the rollers 31, 32 and their contoured surfaces 41 can be analyzed in terms of differential surface velocities that are developed along the contoured surface 41. Since each roller 31, 32 is a unitary element, the angular velocity is the same for any radially directed point at a given radius length. Radially directed points along radii of different lengths will have different angular velocities, which angular velocities are inversely proportional to the radius. For example, when applying this

principle to the contoured surface 41 in Figure 5, the greatest velocity v will be developed along the central radius r, which is the smallest radius on contoured surface 41. A significantly lower velocity v' will be developed, for example, along the portion of surface 41 having a radius r' and that is just out of contact with the transfer tubing 29 when in use. These velocity differences bring about a surface velocity differential which urges the transfer tubing 29 to seek the points on the rollers 31, 32 moving at the fastest velocity, those along radius r, at the axial centers of the rollers 31, 32.

Such curve-contoured roller configuration is also advantageously applied in another aspect of this invention when it is incorporated within blood pumps, roller pumps or other medical equipment, whereby the self-centering attributes thereof eliminate the need for extraneous guide means to maintain the transfer tubing on the pump rollers when they are revolved along the tubing for pumping fluids, particularly blood. Typical prior art pumps, one type of which is illustrated in Figures 6 and 7, include guide means such as transfer tubing clips, straps, or rotating guide rollers. The use of rotating guide rollers is illustrated in Figures 6 and 7 within a blood pump, illustrated generally by 111.

Blood pump 111 has a wall 112 having an inner working surface 113 which is in the form of a right cylinder that has been sectioned longitudinally at its diameter. Rotatably positioned along the axis of the inner working surface 113 is

a longitudinal drive shaft 114 on which is mounted a forked bar 115 for rotatably mounting one or more spool rollers 116 that engage and compress a length transfer tubing 117 as the forked bar 115 is rotated by the longitudinal drive shaft 114, thereby revolving the spool rollers 116 in a path that is spaced from and generally parallel to the inner working surface 113. Were transfer tubing 117 to be simply located between the spool rollers 116 and the inner surface 113 without a suitable guide means, the transfer tubing would have a tendency to slide either upwardly or downwardly off of the spool rollers 116. Such an arrangement would be undesirable because the overall efficiency of the blood pump would then be reduced, the tubing 117 could then move out of engagement completely with the spool rollers 116 and/or the transfer tubing 117 could then be damaged by flanges 118 of the spool rollers 117. Such difficulties are generally eliminated in the prior art, for example, by including upper and/or lower guide members 119, 121, respectively, mounted on transverse bars 122, 123, respectively, that are mounted to and rotate along with the longitudinal drive shaft 114. Usually, the guide members 119 and 121 will be able to rotate along the axis of the transverse bars 122, 123 in order to facilitate their ability to guide the transfer tubing 117 into engagement with the spool rollers 116.

When guide rollers constructed in accordance with the present invention are incorporated into a blood pump or

the like, there is no need to include guide means such as the guide members 119 and their mounting bars 122, 123. Such a blood pump, generally indicated as 131, is illustrated in Figures 8 and 9. Blood pump 131 has a drive shaft 132 onto which is secured a forked bar 115 for rotatably mounting one or more curve-contoured rollers 133 having a structure substantially along the lines of the coacting curve-contoured rollers 31, 32 of the tube stripper 11.

Rollers 133 exhibit self-centering qualities similar to those of the coacting rollers 31, 32, with the major difference being that the inner working surface 113 of the wall 112 of blood pump 131 is the coacting surface for each curve-contoured roller 133, which difference does somewhat reduce the overall advantageous effect of rollers 133 when compared with the coacting rollers 31, 32, particularly because the surface velocity differential is not developed by the right cylindrical inner working surface 113.

It will be apparent to those skilled in this art that the present invention can be embodied in various forms; accordingly this invention is to be construed and limited only by the scope of the appended claims.

I CLAIM:

1. A self-centering roller configuration for fluid transfering medical equipment comprising a roller having an axis and a generally concave surface configuration, said roller having a longitudinal bore along its axis for rotatably mounting said roller on a pivot pin included in a piece of medical equipment, said roller having annular, cylindrical flanges at both of its axial ends with a concave, curve-contoured surface between said annular flanges, said concave, curve-contoured surface being rotatably engageable with a transfer tubing having a predetermined wall thickness, said concave, curve-contoured surface having a uniform longitudinal cross section through said axis of said roller, said uniform longitudinal cross section being a segment of a circle, whereby the efficiency of the fluid-transfering aspects of the medical equipment is increased and a surface velocity differential is developed when said roller is rotated.

2. The self-centering roller configuration of claim 1, wherein said segment of a circle has a radius R determined according to the following equation:

$$R = \frac{Y^2 + 4X^2}{8X}$$

wherein Y is the chordal length of said segment and X is the height of said segment plus one-half of a flange clearance.

3. The self-centering roller configuration of claim 2, wherein X is equal to or less than said predetermined wall thickness of the transfer tubing.

4. The self-centering roller configuration of claim 2, wherein said transfer tubing has deformable, resilient walls, and wherein X is less than said predetermined wall thickness by the amount of an occlusion factor.

5. In an improved blood donor tube stripper including a first pliers arm having a laterally extending pivot rod, a second pliers arm having a lateral pivot bore, said first pliers arm being pivotally joined to said second pliers arm by passing said laterally extending pivot rod through said lateral pivot bore, said first pliers arm and said second pliers arm each having a working end, a first pivot pin rigidly secured to said working end of the first pliers arm, a second pivot pin rigidly secured to said working end of the second pliers arm, a roller having a longitudinal axis and being rotatably mounted onto each of said first pivot pin and said second pivot pin, said rollers being located to coact with each other to compress a length of transfer tubing having a wall thickness and to strip blood from therewithin, the improvement comprising: said rollers each having a self-centering configuration, said

rollers each having a generally concave curve-contoured surface between annular, axially extending flanges at both of the axial ends of each roller, said concave surface having a uniform longitudinal cross section through said axis of each roller, said uniform longitudinal cross section being a segment of a circle, whereby the stripping efficiency of the blood donor tube stripper is increased and a surface velocity differential is developed when said rollers are rotated as the blood donor tube stripper is used.

6. The blood donor tube stripper of claim 5, including an adjustable stop between said working ends of the first and second pliers arms, said adjustable stop cooperating with said axially extending annular flanges of said rollers to securely align the rollers when in stripping use.

7. The blood donor tube stripper of claim 5, wherein said first and said second pivot pins each have a non-rotatable annular, axially-extending head at the remote end of each said pin, and wherein the transfer tubing is maintained out of contact with said heads.

8. The blood donor tube stripper of claim 5, wherein said segment of a circle has a radius R determined according to the following equation:

$$R = \frac{Y^2 + 4X^2}{8X}$$

wherein Y is the chordal length of said segment and X is the height of said segment plus one-half of a flange clearance.

9. The blood donor tube stripper of claim 8, wherein X is equal to or less than said wall thickness of the transfer tubing.

10. The blood donor tube stripper of claim 8, wherein said transfer tubing has deformable, resilient walls, and wherein X is less than said wall thickness by the amount of an occlusion factor.

11. In an improved roller pump for medical equipment including an inner generally cylindrical surface having a longitudinal axis, a drive shaft rotatably mounted along said drive shaft, a forked bar rigidly secured to said drive shaft, a roller rotatably mounted onto an end of said forked bar that is remote from said drive shaft, said roller being mounted to follow a path spaced from and generally parallel to said inner working surface in order to compress a length of transfer tubing and force fluid through said length of transfer tubing, the improvement comprising: said roller having a self-centering

configuration, said roller having a generally concave curve-contoured surface between axially-extending annular flanges at both axial ends of said roller, said concave surface having a uniform longitudinal cross section through said roller axis, said uniform longitudinal cross section being a segment of a circle, whereby the pumping efficiency of the roller pump is maintained while avoiding the need to include guide means for said length of transfer tubing extraneous to said roller.

12. The roller pump of claim 11, wherein said segment of a circle has a radius R determined according to the following equation:

$$R = \frac{Y^2 + 4X^2}{8X}$$

wherein Y is the chordal length of said segment and X is the height of said segment plus one-half of a flange clearance.

13. The roller pump of claim 12, wherein X is equal to or less than said wall thickness of the transfer tubing.

14. The roller pump of claim 12, wherein said transfer tubing has deformable, resilient walls, and wherein X is less than said wall thickness by the amount of an occlusion factor.

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FIG_2_
PRIOR ART

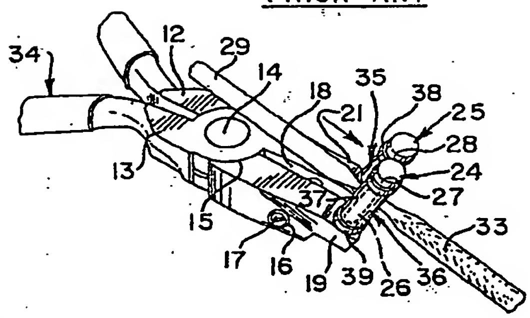

FIG_1_

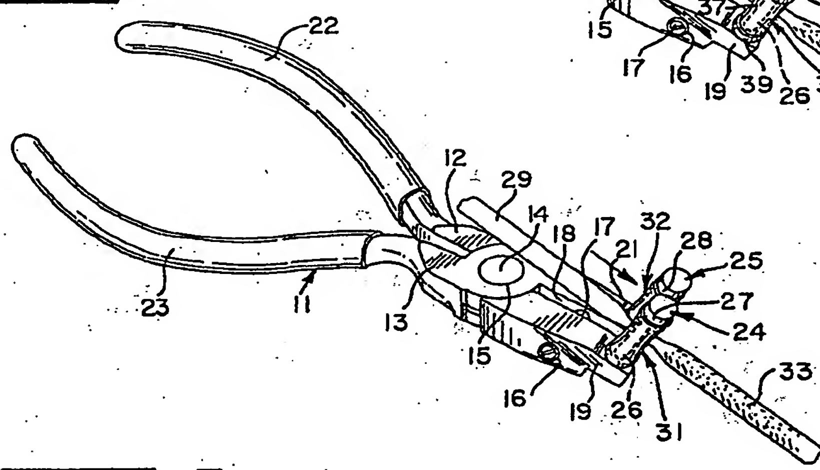

FIG_3_

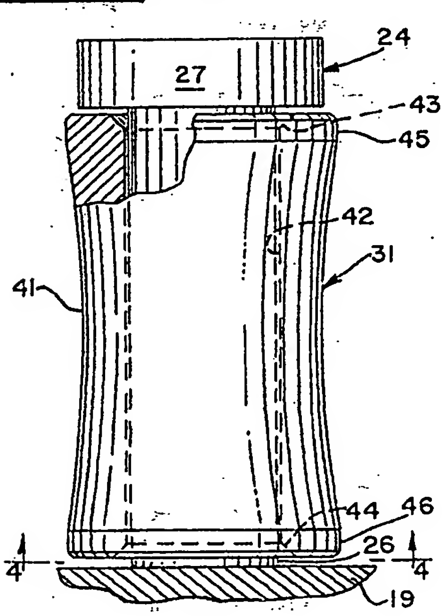

FIG_4_

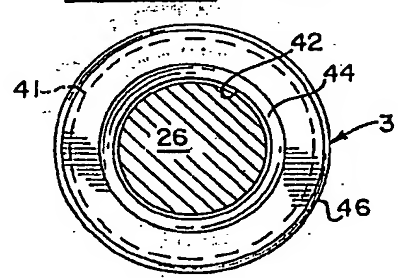

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FIG. 5

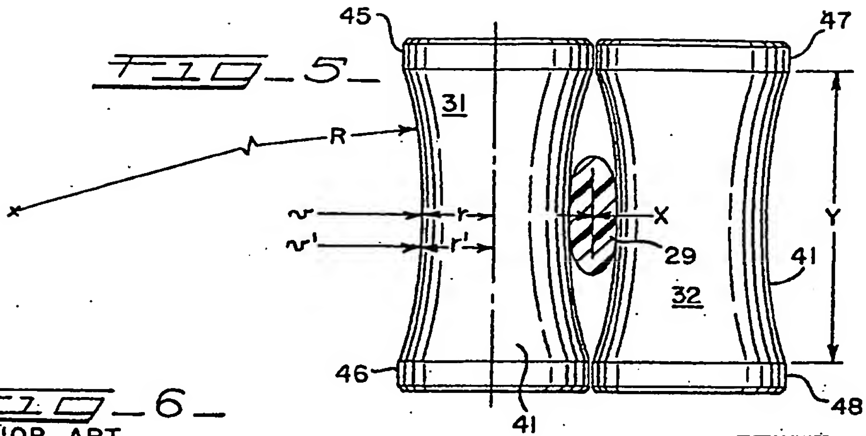


FIG. 6
PRIOR ART

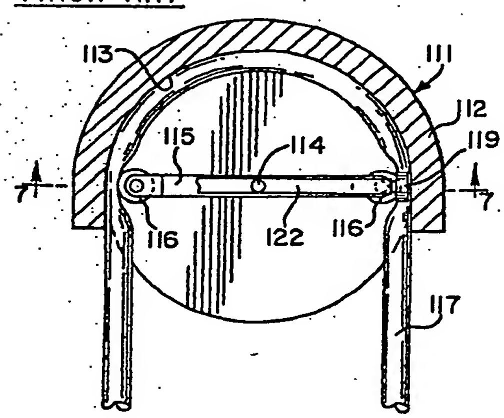


FIG. 8

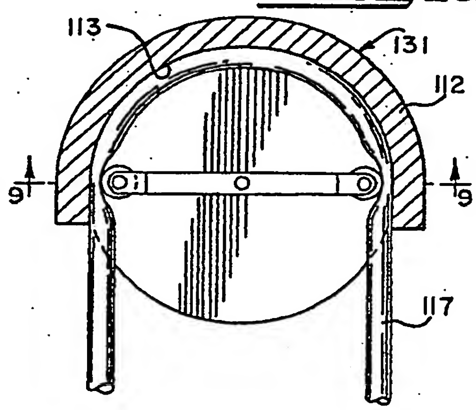


FIG. 7
PRIOR ART

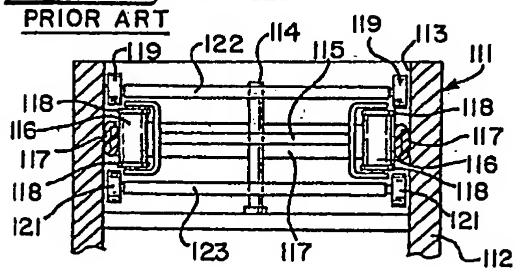
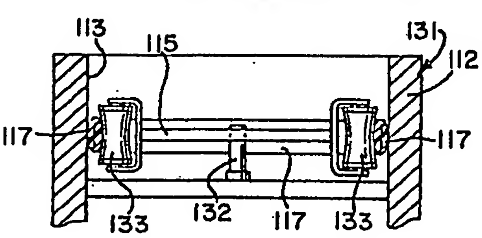


FIG. 9



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